5313

ALLENDE 3509 HC-2: A COMPACT TYPE A—'F' INCLUSION WITH A SNAKE-LIKE MORPHOLOGY

H. C. Connolly Jr.[1,2,3], J. R. Beckett[4], G. R. Huss[5], K. Nagashima[5], E. D. Young[6], K. Ziegler[6], C. Ma[4] and G. R. Rossman[4]. [1]Dept. Physical Sci., Kingsborough Community College of CUNY, Brooklyn NY 11235 & Dept. Earth & Envir. Sci., The Graduate Center of CUNY, New York, NY 10016, USA. [2]Dept. Earth & Planet. Sci., AMNH, New York, NY 10024, USA. [3]LPL, Univ. of Arizona, Tucson, AZ 85721, USA. [4]Div. of Geol. & Planet. Sci., Caltech, Pasadena, CA 91125, USA. [5]Hawai'i Institute of Geophysics & Planetology, Univ. of Hawai'i at Mãnoa, Honolulu, HI 96822, USA. [6]Dept. of Earth & Space Sci., UCLA, Los Angeles, CA 90095, USA. E-mail: chondrule@haroldconnolly.com.

Introduction: Calcium-, aluminum-rich inclusions (CAIs) are the first rocks to form in the solar system. Some inclusions are igneous and a very few of these (called F inclusions) experienced significant mass dependant fractionation in oxygen [1], and in some cases, other isotopic systems (FUN inclusions). Increasing the number and types of F inclusions will provide additional constraints on CAI formation and their formation environments. We report here on a Compact Type A (CTA) inclusion from Allende with an overall snake-like morphology, is an F inclusion, and initial $^{26}Al/^{27}Al$ that was canonical.

Analytical Methods: The entire inclusion, HC-2, was recovered from a slab of Allende 3509 (USNM). Major and minor element abundances were determined with the Cameca SX-50 at the LPL UAz. Oxygen isotopes and Al-Mg isotopic systematics were analyzed for on the Cameca 1280 ion microprobe at the Univ. of Hawai'i, Mãnoa [2]. Si isotopes were analyzed by LA-MC-ICPMS at UCLA.

Results: HC-2 has an overall morphology that is snake-like, wrapping throughout a 1.5 cm thick (total width is approximately 0.75 cm) section of the meteorite, inspiring it to be nicknamed The Snake. It has a Wark-Lovering rim on both sides, although the rim is thicker on one side. The inclusion has experienced some brittle deformation. HC-2 is dominated by spinel (Ti = 0.14–0.37; V = 0.44–0.64; Cr = 0.08–0.14; all wt%) and melilite (Ak = approximate 4 to approximate 50). Perovskites are numerous, ranging in size from sub-micron to approximately 0.5 mm. There appear to be two smaller (approximately 400 μm) CAIs that are mineralogically layered included.

SIMS analysis on spinel and melilite yield an isochron with an initial $^{26}Al/^{27}Al$ of $(4.9 \pm 0.2) \times 10^{-5}$. ÁÂ^{25}Mg (variations from the standard in stable Mg isotope) range from approximately 5 to 13‰. *Oxygen isotopes:* Melilites have $\delta^{18}O$- $\delta^{17}O$- values that span approximately 10‰ and plot on the CCAM line near the TF line. Two perovskite grains are isotopically different with $\delta^{18}O$, $\delta^{17}O$ of (in ‰) approximately −28, −31 in one and −40, −44 in the other. Overall, the spinels are ^{16}O-rich and show a clear mass fractionation of 4‰ amu^{-1}, ($\delta^{18}O$ = −34 to −42‰; $\delta^{17}O$ = −41 to −45‰) with the overall trend to the right of the CCAM line.

Conclusion: HC-2 is clearly igneous. The reason for its unusual shape is not clear, but it must have formed while plastic. Based on the stable isotope data, HC-2 experienced considerable mass-dependent isotopic fractionation, most likely while molten and while ^{26}Al was present. We will compare our data to other 'F' inclusions to place new constraints on CAI formation and the environment in which they formed.

References: [1] Bullock E. S. et al. 2011. Abstract #2312. 42nd Lunar and Planetary Science Conference. [2] Kentaro et al. 2009. *Geochimica et Cosmochimica Acta*. [3] Shahara and Young. 2009. *Earth and Planetary Science Letters*.

5054

MAJOR AND TRACE ELEMENTS AND OXYGEN ISOTOPES IN DIFFERENTIATED COSMIC SPHERULES RELATED TO VESTA-LIKE ASTEROIDS

C. Cordier[1], L. Folco[1], C. Suavet[1], P. Rochette[2] and C. Sonzogni[2]. [1]MNA, Siena, Italy. E-mail: cordier@unisi.it. [2]CEREGE, Aix-en-Provence, France.

Cosmic spherules (CSs) are extraterrestrial particles < 2 mm in size, captured by the Earth's gravitational field and melted during atmospheric entry. Generally, CSs have geochemical affinities with chondritic material [1]. The ongoing investigation of large and unbiased collections of CSs from the South Pole Water Well and the Transantarctic Mountains (TAM) have, however, led to the identification of new types, including nine differentiated CSs [2, 3]. Here, we define the geochemical characteristics of this new type of CSs from the TAM collection [4] in terms of major (n = 11, EPMA), trace element (n = 6, LA-ICP-MS) and oxygen isotope (n = 15, IRMS) compositions.

The 11 differentiated CSs have high Fe/Mg ratios (0.6–1.6) and homogeneous Fe/Mn ratios (31 ± 4). Oxygen isotope compositions ($\delta^{18}O$ = 14.37% to 20.12 % and $\Delta^{17}O$ = −0.47% to −0.65%) suggest a Vesta-like parent body. Systematic variations in refractory major and trace elements result from differences of the mineralogy of the spherule precursors. Type-1 spherules (n = 4) are akin to bulk eucrites, with high CaO and Al_2O_3 contents, flat REE patterns and high REE contents (La/Yb_N = 0.4 to 1.0, REE_N = 8.5 to 14 × CI). They derive from fine-grained precursors with typical eucritic mineralogy. Type-2 spherules (n = 4) have lower CaO and Al_2O_3 contents, higher MgO, FeO, and Sc contents, and strong LREE depletions (La/Yb_N < 0.2) relative to eucrites. These compositions suggest large amounts of pigeonite in their precursors. Type-3 spherules (n = 2) have flat REE patterns with chondritic REE abundances (REE_N = 1.5 to 2.2 × CI), and are enriched in Co (> 50 μg g^{-1}) and Ni (> 17 μg g^{-1}) relative to eucrites. Their composition suggests they derive from howardite-like precursors rich in orthopyroxene. The mineralogies proposed for the differentiated precursors are consistent with those expected for micrometeoroids deriving from the regolith of Vesta-like asteroids [5].

The combination of elemental and isotopic data shows that the elemental ratios and contents (Fe/Mg and Fe/Mn, REEs, Ni and Co, V, Zn) previously proposed to identify the differentiated CSs and their parent body [3] are suitable, provided that the mineralogical control is understood. Differentiated CSs deriving from pigeonite-rich precursors (Type 2) tend to have slightly lower Fe/Mg and Fe/Mn ratios and higher V contents than basaltic eucrites, whereas large amount of opx in spherule precursor may result in lower Fe/Mg and higher Ni and Co contents.

The relative frequency of Vesta-like micrometeorites in the TAM micrometeorite collection (1.6%) is consistent with the proportion amongst meteorites of eucrites and howardites (1.8%), which are the main constituents of the regoliths of Vesta-like asteroids.

Acknowledgments: This work was supported by the PNRA and by the EU-funded ORIGINS Marie Curie Action.

References: [1] Engrand C. and Maurette M. 1998. *Meteoritics & Planetary Science* 33:565–580. [2] Taylor S. et al. 2007. *Meteoritics & Planetary Science* 42:155–304. [3] Cordier et al. 2011. *Geochimica et Cosmochimica Acta* 75:1199–1215. [4] Rochette P. et al. 2008. Proceedings of the National Academy of Sciences 105:18206–18211. [5] Burbine T. H. et al. 2009. *Meteoritics & Planetary Science* 44:1331–1341.